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Two experiments investigate the effects of mode of presentation and number of categories on 4-year-olds' proportion estimates. Experiment I compares simultaneous and successive presentations of proportion problems using two categories of elements. The subjects were 40 children chosen randomly and tested individually. Four problems were presented simultaneously to one half of the children, and given successively to the other. The results indicate that 4-year-olds are fairly accurate in their estimates and are able consistently to discriminate proportions differing by .20, but not by .10. The results replicate fairly well an earlier study by Ginsburg (1967). There were no significant differences in estimates of proportion as a result of mode of presentation. Experiment II studied the effects of three categories of elements presented simultaneously. The subjects were thirteen 4-year-olds chosen randomly. The results show that estimates are different from and poorer than those of two category problems, and the children performed approximately at chance level. (JF)

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The effects of mode of presentation and number of categories on 4-year-olds' proportion estimates

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The effects of mode of presentation and number of categories on 4-year-olds' proportion estimates[1]

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The present experiments investigate estimates of proportion in 4-year-old children.

In a study by Ginsburg (1967) of simultaneous estimates of proportion, individual children were presented with 20 x 20 matrices of two categories of elements (X's and O's). Ss were asked to estimate the proportion of elements in each category. These judgments were made with the aid of a special apparatus (to be described in detail below), which did not require the Ss to employ numerical operations, and was thus suitable for use by young children. It was found that there were no significant differences among the estimates of 4-, 7-, and 12-year-olds. All age groups were fairly accurate. Proportions differing by .20 were consistently discriminated, although this was not always the case with proportions differing by .10. The results for the 4-year-olds seem surprising since children of this age are usually considered to have poor quantitative abilities. Consequently, the first purpose of Experiment I is to determine whether Ginsburg's results can be replicated.

The second purpose of Experiment I is to determine the effect of mode of presentation on 4-year-olds' estimates. Proportion problems may be presented in either a simultaneous or successive way. The

simultaneous procedure has already been described (matrices of X's and O's). The successive procedure involves presenting Ss with a sequence of elements, one at a time, where the elements are never seen in a collection. The question then arises as to whether mode of presentation affects 4-year-olds' proportion estimates. Consequently, in Experiment I, 4-year-old children were given several different proportion estimation problems, under either simultaneous or successive conditions.

Experiment I

Method

Design

Four-year-old children, seen individually, were all given four different proportion problems. In the case of one half of the children, the problems were presented in a simultaneous way; for the other half, problems were presented successively. The order of the four problems was randomized and another minor variable was counterbalanced. In summary, the design involved two modes of presentation and four different problems.

Subjects

The Ss were 40 children, chosen randomly from class rolls, at several different schools. Within each school the Ss were assigned randomly and in equal numbers to the two different conditions. In the simultaneous condition, the mean age, in terms of years and months, was 4-4 (range 3-5 to 5-1). In the successive condition, the mean age was 4-5 (range 3-5 to 5-3).

Procedure

In the simultaneous condition, each S, seen individually, was presented with a series of 20 x 20 matrices of X's and O's, which were typed on white paper. The matrices were approximately 7 in. high and $8\frac{1}{2}$ in. wide, and were pasted on white posterboard of about the same size. The matrices were held up by E, one at a time, at about a 110° angle from the table facing the S and about two feet from him. There was a total of seven matrices. Three were practice problems and four were test problems. The first practice problem involved 88 percent X and 12 percent O, and the second practice problem involved 33 1/3 X and 66 2/3 O. The third practice problem had 50 percent X and 50 percent O. The percentages in the test problems were: (1) 40,60, (2) 30,70, (3) 20,80, (4) 10,90. Half the Ss saw 40 O, 30 X, 20 X, 10 O, and the other half saw 40 X, 30 O, 20 O, 10 X. In all the matrices, the X's and O's were arranged randomly, by means of a table of random numbers. Ten different random orders of presentation of the matrices were used.

E began by showing each S the first practice matrix. "We're going to play a game with X's and O's. Here is a card with X's and O's. Can you show me an X? Can you show me an O?" To ensure that each S knew which was X and O, E pointed to one of each letter and quizzed the S. If the S did not at first know the letters, E asked him to say which was which and started the training procedure only after three or four consecutive correct responses. Only about one quarter of the Ss required practice with the letters. "Now take a close look at the

card. Now we just saw lots of X's and just a few O's, didn't we? Good. Here's a way you can show me that you saw lots of X's and just a few O's." At this point E introduced a special apparatus. This was a large board, 23 in. long, 4 in. wide, and 1 in. deep. Along the length of the board were cut two grooves, separated by 1 in. Within one groove was a length of cardboard on which was printed a line of 41 X's; the second groove contained a line of 41 O's. Over each groove (and line of X's and O's) was a thin strip of wood which could be moved so as to reveal as many of the X's and O's as desired. S was shown how to do this. E continued, "You could move this way up to show me lots of X's and move this line up just a little bit to show me just a few O's. There are lots of X's here and just a few O's here, see?" E uncovered the lines in the correct ratio of 7X:10. Then S was asked, "Now why don't you show me what we just saw." After S made an estimate on the board, E corrected it if necessary. Then S was shown the second practice matrix and E essentially repeated the instructions, showing S the correct ratio, and correcting his estimate. Then E showed S the third practice matrix. E said, "This card has the same number of X's and O's. How would you show me that?" After S made an estimate, E corrected it, if necessary. E said, "Now I'm going to show you some more cards and I want you to show me on this board how many X's and O's there are on each card. Look real hard at the card. You can take as long as you like. Don't wait for me to tell you what to do. I will tell you after you are all through how well you did." Next E presented the four test problems, in one of the 10 random orders. At no point after the

practice problems did E give S feedback concerning correctness of response. The entire procedure required about 15 to 20 minutes on the average. In sum, Ss were shown four test problems, and were required to produce ratio estimates of the X's and O's in each matrix.

In the successive condition, each S was given three practice problems and four test problems, identical in proportion to those in the simultaneous condition. E began by showing to the S a covered paper cup. The cup was filled with pieces of white paper about 2 in. square with either an X or an O printed in large black letters on both sides. E said, "We're going to play a game with X's and O's. In this box I have some X's and O's. I'm going to shake this box up [without looking] and then pull each card out one at a time, and I'd like you to tell me what each one is when I pull it out." After showing each card to the S, E hid it. When the total contents of the container (8 cards) were shown to the S and hidden from him, he was instructed to make his estimate by means of the same apparatus used in the simultaneous condition. The rest of the training and test procedure was identical to the simultaneous condition. Each successive test problem involved a total of 20 letters.

Results

The major dependent variable is the proportion of X's and O's uncovered by S for each problem. Table 1 shows the mean estimates for each problem in each condition. A 2 x 4 (mode of presentation

Insert Table 1 about here

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by problems) analysis of variance, with repeated measures on the second factor (Winer, 1962), was performed on the proportion estimates of the more frequent category in each problem. The only significant effect was that due to problems (F = 8.20, df = 3,114, p <.01).

The Newman-Keuls procedure was used to make individual comparisons among the mean estimates (averaged across mode of presentation, because of its nonsignificant effect). This analysis shows that the mean estimate for the 60 percent problem is significantly different from the estimate of the 70 percent problem (p <.05), of the 80 percent problem (p <.01), and of the 90 percent problem (p <.01). The 70 percent problem is not significantly different from the 80 percent problem but is different from the 90 percent problem (p <.05). The 80 percent estimate is not significantly different from the 90 percent estimate.

During the testing situation, it seemed to the E that the younger children did not perform as well as the older. To test this possibility, a correlation was computed between the "accuracy" scores and the Ss' chronological age. The "accuracy" scores represent the absolute difference between the S's estimate and the real proportion. For example, if the S's estimate was either 85 or 95 on the 90 percent problem, his accuracy score would be 5. The correlations were computed for each problem separately, combining Ss from both modes of presentation, since there was no difference between them. The correlations for the 60, 70, 80, and 90 percent problems, respectively, are: r = -.15 (df=38, p >.05), r = -.09 (df = 38, p >.05), r = -.30 (df = 38, p <.05), and r = -.40 (df = 38, p <.01).

Discussion

The first question asked was whether Ginsburg's (1967) results could be replicated. Table 1 shows that the means from the simultaneous

condition of the present study and Ginsburg's are similar. In the 60 and 70 percent problems, there is approximately a 5 point difference between the two sets of data; in the 80 and 90 percent problems the difference is about 8 points. In all cases, the Ginsburg means are higher than the present ones. Also, in both the present study and Ginsburg's, 4-year-olds are able consistently to discriminate among proportions differing by .20, but not .10. In general, then, the Ginsburg results and the present ones are similar, and the replication may be considered to have been fairly successful.

The results failed to show a significant effect of mode of presentation. Probably, one would have expected , on intuitive grounds, that simultaneous presentation would have been easier for the children, but this was not the case.

The results showed significant correlations between <u>S</u>s' accuracy and chronological age, in the case of the 80 and 90 percent problems, but not the 60 and 70. There may be several reasons for the differences in significance. One is that, in the 60 and 70 percent problems, even a <u>S</u> who guesses is apt to produce fairly accurate estimates, because the real proportions are close to 50 - 50. Consequently, the better test of <u>S</u>s' ability is in the case of 80 and 90 percent problems, and it was in these that the significant correlations were found. These correlations, although statistically significant, were quite low (-.30 and -.40), accounting for little of the variance. Apparently, even some very young children are capable of fairly accurate proportion estimates. But the matter requires further clarification. The

present study employed a chronological age measure, whereas a mental age score is preferable.

Future studies in this area should also attempt to raise the level of Ss' motivation. The Es noticed informally that some Ss were easily bored with the task, with the result that their performance seemed to suffer. If interest could be heightened, perhaps the general level of accuracy of 4-year-olds will improve.

Experiment II

Ginsburg and Rapoport (1967) studied the effects of number of categories on 6- and 11-year-old children's estimates of successively presented proportions. They presented Ss with either white and black marbles (two categories) or white, black, and yellow marbles (three categories). These investigators found that the age groups' estimates did not differ in the two category case and that both were fairly accurate. In the three category condition, however, 11-year-olds were significantly more accurate than 6-year-olds, although this latter group performed at a level better than that expected by chance. Another way of looking at the results is to say that 6-year-olds performed more poorly on a three category task than on a two. The results were interpreted as showing that in the case of proportion estimates, there is a limit on the amount of information which 6-year-olds can process effectively.

The present experiment attempts to determine whether similar deficiencies characterize the performance of 4-year-olds. One might predict. on the basis of the Ginsburg and Rapoport results, that

4-year-olds perform more poorly on a three category estimation task than on a two.

Method

Design

Thirteen 4-year-old children, seen individually, were given four proportion problems. Each involved three categories of elements presented simultaneously. The order of the problems was randomized, and another minor variable was counterbalanced.

Subjects

The Ss were 13 4-year-olds chosen randomly from class rolls. The mean age in terms of years and months was 4 - 9, with range 3 - 10 to 6 - 2.[3]

Procedure

The procedure for this study was substantially the same as that followed in Experiment I. Ss were presented with three practice problems and four test problems all involving 20 x 20 random matrices of X, O, and M. The percentages of X, O, and M in the training problems were respectively (1) 64, 24, 12, (2) 22, 67, 11, (3) 33, 33, 33. The percentages in the four test problems were: (1) 60, 30, 10, (2) 70, 20, 10, (3) 80, 15, 5, (4) 90, 5, 5. Note that the percentage of the most frequent category in each problem is the same as the percentage of the more frequent category in each problem of Experiment I. The letter (X, O or M) occupying the most frequent position in each problem was counterbalanced. There were seven different random orders of presentation of the test problems. The

apparatus was the same as that employed in Experiment I, except, of course, for the addition of a third line of M's. Also, the instructions were substantially the same as those employed in the first study. In sum, Ss were presented with four test problems and were required to produce ratio estimates of the categories of elements in each matrix.

Results and Discussion

Table 2 shows the mean estimates for the test problems. All

Insert Table 2 about here

of the estimates are near 33 percent. This is the result expected if Ss were incapable of discrimination among the categories. No statistics are required to show that 4-year-olds' estimates of three category simultaneous problems are quite different from and poorer than those of two category problems. These results parallel the findings of Ginsburg and Rapoport. One exception is that in the present case three category estimates were approximately at a chance level, whereas in the Ginsburg and Rapoport study, the three category estimates, although poorer than the two category estimates, nevertheless involved fair discrimination among the categories. It is still an open question, of course, as to how 4-year-olds perform on three category successive problems.

Conclusions

The present studies substanially replicate the findings of Ginsburg (1967) concerning 4-year-olds' estimates of simultaneous proportions; extend the research to the case of successively presented proportions; and confirm

the trends noted in Ginsburg and Rapoport (1967) concerning the effects of number of categories on children's estimates. Clearly, the empirical facts concerning children's proportion estimates are now well established. All of the studies in this area yield remarkably consistent results.

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Footnotes

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2. The writers are in the Department of Child Development and Family Relationships at Cornell.
3. Without the child aged 6-2, the range would be 3-10 to 5-1.

Table 1

Mean estimates for simultaneous and successive modes of presentation

	Real Percentages			
	60	70	80	90
Simultaneous mean estimates	50.6	55.2	58.9	63.6
Successive mean estimates	52.8	57.8	58.7	61.0
Simultaneous mean estimates (Ginsburg, 1967)	55.6	59.7	65.3	71.8

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Table 2

Simultaneous three category estimates

	Real Percentage			
	60	70	80	90
Mean estimates	38.2	33.0	38.1	44.2

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